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SUFFOCATION INHIBITING INHALATOR-EXHALATOR VALVE

Filed March 28, 1961

2 Sheets-Sheet 1

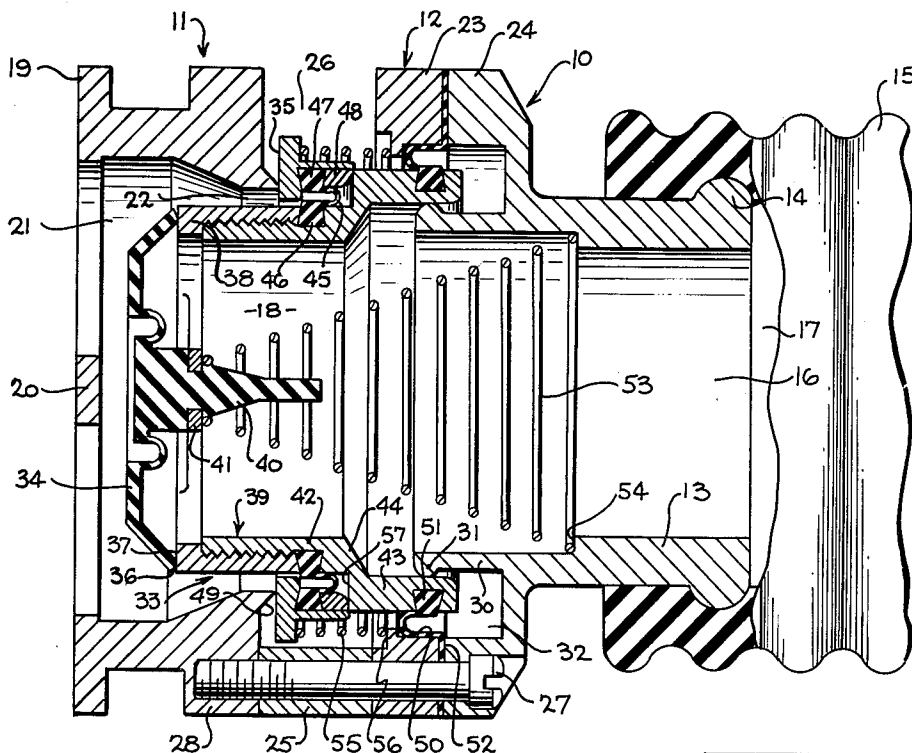


Fig. 1

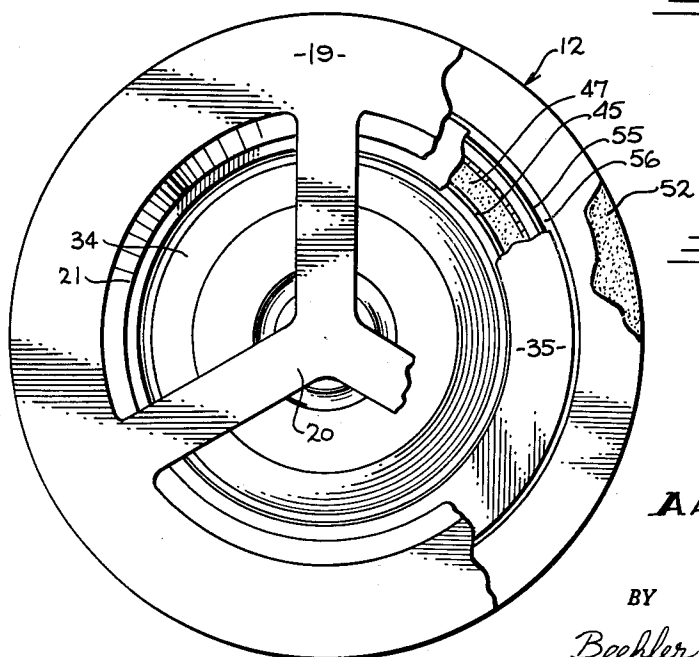


Fig. 2

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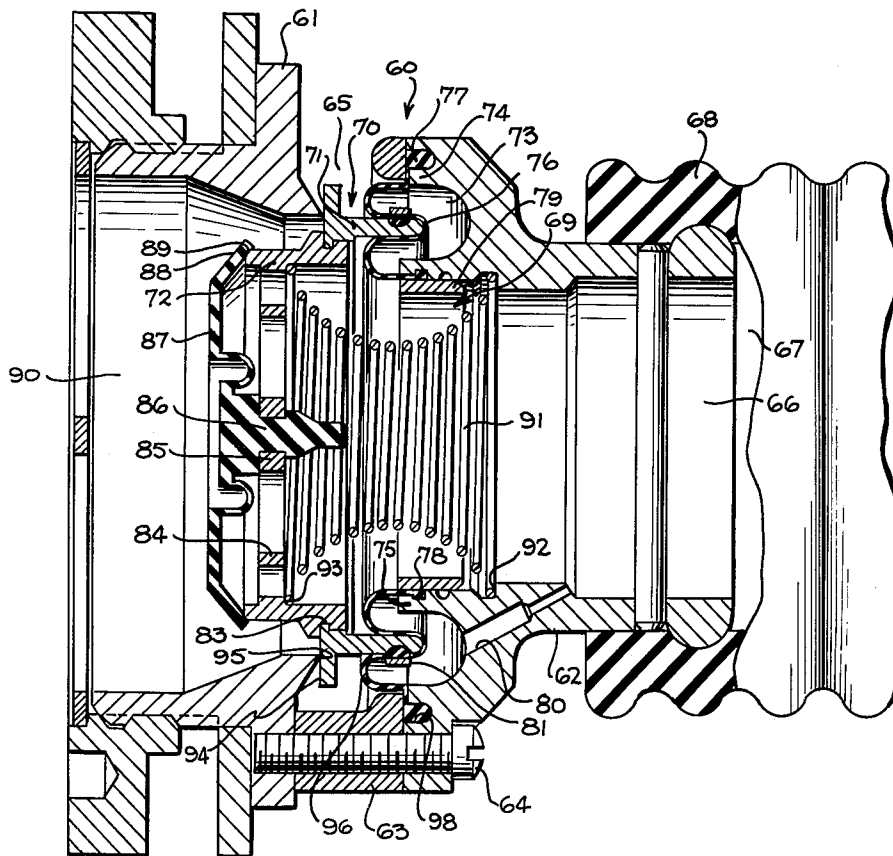


Fig. 3

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SUFFOCATION INHIBITING INHALATOR-EXHALATOR VALVE

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3 Claims. (Cl. 137—64)

The invention relates to breathing valves of the type used on respiratory apparatus and more particularly is concerned with a valve which admits air or oxygen from a source of supply to a breathing mask and which shuts off the supply when the user exhales through the valve, permitting the exhaled gases to escape. More particularly, the valve is one designed inherently in such fashion as to inhibit suffocation in the event that the oxygen or gas supply becomes shut off or depleted.

Among the various valves heretofore designed for supplying oxygen to a breathing mask, sundry safeguards have been incorporated which for the most part have necessitated adding various accessories to what would otherwise be a relatively simplified valve construction. Despite the complicating of these valves to such a degree, the safeguards have, however, been worthy of inclusion and sufficient to warrant the departure from simplification. One contingency, however, has as yet not been adequately provided against, especially with a simple valve type structure which works smoothly and which gives adequate insurance, namely, the possibility of suffocation or semi-suffocation of a person using an oxygen or air supply under conditions where the ambient air of the locale in which the user is situated contains at least some oxygen and where the supply of oxygen or air becomes inadvertently cut off or depleted. Under those circumstances with the mask still in place, the valving ordinarily becomes obstructed and particularly the exhalation valving so that, although the user can exhale, he becomes unable to inhale through the exhalation valve and therefore suffers because there is no air or oxygen supplied through the inhalation valve due to depletion.

It is therefore among the objects of the invention to provide a new and improved combination inhalator-exhalator valve device which is so constructed inherently that it is capable of inhibiting suffocation in the event of a cut off or depletion of the oxygen or air supply. Another object of the invention is to provide a new and improved combination inhalator-exhalator valve device constructed in a simple fashion by a rearrangement of the proportions of surfaces of a moving valve element subjected to inhalation and exhalation pressures such that when the pressure condition within the valve is changed during inhalation cycle under circumstances where there is a depletion of supply, the exhalation valve will open and simultaneously permit the user to inhale ambient air through the exhalation valve, thereby to fill his lungs to the full volume before exhaling and accordingly inhibit suffocation.

Another object of the invention is to provide a new and improved combination inhalator-exhalator valve device which is of specially simplified construction and so constructed that the action of the movable valve elements is dampened or cushioned by regular oxygen or air pressures within it, thereby to prevent chatter and flutter, especially under circumstances where the breathing is rapid and accordingly improve the reliability and dependability of performance under a wide variety of circumstances.

Still another object of the invention is to provide a new and improved combination inhalator-exhalator valve device which makes use of a plurality of flexible elements interconnecting sundry moving parts of a composite valve

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element, thereby adding considerable flexibility to the action of the moving valve element while at the same time keeping it dependably centered with respect to the seat.

Also included among the objects of the invention is to provide a new and improved combination inhalator-exhalator valve, the construction of which permits critical parts to be made separately to exceptionally close tolerances and thereafter assembled by an easy assembly operation into a unitary valve device which, while inexpensive, is also dependable.

This application is a continuation-in-part of copending application Serial No. 801,591, filed March 24, 1959 and now Patent #3,035,594.

With these and other objects in view, the invention consists in the construction, arrangement and combination of the various parts of the device, whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a longitudinal sectional view of one form of the valve device which incorporates as a feature hose pull protection.

FIGURE 2 is an end elevational view of the device of FIGURE 1 partially cut away.

FIGURE 3 is a longitudinal sectional view of a modified form of the device wherein the structure of the composite movable valve portions has been modified.

In an embodiment of the invention chosen for the purpose of illustration there is shown a combination inhalator-exhalator valve device which comprises a composite body consisting in the main of three elements, namely, a base or supply end member 10, a cap or mask end member 11, and a spacer 12. On the base is a neck 13 provided with a bead 14 for attaching and securing a length of supply hose 15 thereto. Within the neck is a supply passage 16 which communicates with the interior 17 of the supply hose on one side and a supply chamber 18 on the opposite side.

The cap 11 is provided with a connection 19 by means of which the valve can be attached to a breathing mask (not shown). A spider 20 serves to reinforce the structure of the cap adjacent a passage 21 by means of which air passes between the mask and an exhalation chamber 22.

The spacer 12 is an annular sleeve-like element consisting of a portion 23 attached to an annular flange 24 of the base and an extension 25 serving to space the portion 23 from the cap to provide exhalation ports 26, one of which is shown in FIGURE 1. The parts are held together by screws 27, as shown in FIGURE 1, wherein the screw extends through the flange 24, the portion 23, and extension 25 into a flange 28 on the cap. When these portions are connected together as shown, they form in essence the valve body comprising the rigid portion of the structure.

Within the base is a guide ring 30 spaced inwardly from the flange 24, leaving an annular space 32 therebetween. A bead 31 is provided on the free end of the guide ring 30. The interior of the combination valve consists in the main of a relatively composite axially shiftable sleeve indicated generally by the reference character 33 which mounts an inflow check valve 34 and an exhalation check valve 35.

The inflow check valve 34 is one wherein the valve element is flexible so that an annular edge 36 normally seats upon an annular valve face 37. The annular valve face is formed upon a ring 38 which is threadedly attached to a sleeve 39. A valve stem 40 is secured in a spider 41 which is part of the ring 38. Upon the inhalation phase of the operation, the edge 36 lifts from the valve face due to the resiliency of the valve element.

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The sleeve 39 has a section 42 of relatively smaller diameter and a section 43 of relatively larger diameter joined by an intermediate section 44. The section of relatively larger diameter is formed to provide a free sliding fit over the bead 31 of the guide ring 30.

On the section of relatively smaller diameter there is provided a flexible annular seal 45 having one enlarged edge 46 confined in air-tight relationship with the section 42 by use of the ring 38 and another edge 47 anchored in the exhalation check valve 35 by means of a snap ring 48. The exhalation check valve comprising in essence a flat annular valve seat cooperates with an annular knife edge valve element 49 upon the flange 28 of the cap 11.

A second flexible annular seal 50 has one enlarged edge 51 confined in the section 43 of larger diameter and has at the other edge an annular flat section 52 which is confined in sealed relationship between the portion 23 of the spacer 12 and the adjacent space of the flange 24 of the base. The two seals 45 and 50 are of loose fitting character to permit an ample degree of movement of the adjacent parts to which they are attached.

A spring 53 contained upon a shoulder 54 in the base is pressed against the spider 41 and acts to urge the sleeve 33 in a direction from right to left whereby to press the exhalation check valve seat against the valve element 49. This is accomplished by pressure of a land 57 of the sleeve 39 against the adjacent portion of the exhaust check valve 35.

A second and lighter spring 55 bearing upon a shoulder 56 on the portion 23 serves to additionally urge the exhalation check valve 35 to a valve closed position against the valve element 49.

When in normal operation during the inhalation cycle the inflow check valve lifts when gas is supplied from the supply 16 to the mask. During this portion of the cycle the exhalation check valve is closed. Upon the exhalation cycle, the inflow check valve 34 is forced upon its seat by air pressure from the lungs and the pressure acts against the sleeve 33, moving it in a direction from left to right. The air pressure at the same time acts upon the exposed annular flat face of the exhalation check valve and overcomes tension of the spring 55 whereby to unseat the exhalation check valve and permit exhaust of gases from the lungs flowing through the device.

Should there be an inadvertent pull upon the hose 15 tending to lengthen the hose slightly and increase the volume of the interior hose passage, this action would tend to lower the pressure in the supply line and cause the composite sleeve 35 to shift in a direction from left to right, as viewed in FIGURE 1. Were it not for the presence of the spring 55 and independent action of the exhalation check valve 35, this last identified valve would be inadvertently unseated as a result of pull upon the hose. Unseating is prevented in applicant's structure by reason of the fact that although the composite sleeve 33 is shifted in a direction from left to right when pressure in the inflow passage 16 is lowered as a result of pull upon the hose, the exhalation check valve remains seated against the valve element 49 because the seal 45 is flexible whereby the spring 55 holds the exhalation check valve against the seat, even though the composite sleeve be moved.

Should pull continue upon the hose during several breathing cycles, the presence of pull would have no effect upon operation of the exhalation check valve when the user needs to exhale because exhalation pressure would be exercised against that portion of the exhalation check valve within the valve element 49 and would overcome tension of the spring 55 sufficient to unseat the valve and permit exhaust gases to escape through the exhalation ports 26. During the inhalation cycle, while pull remains upon the hose, the inhalation check valve operates in the customary fashion and the spring 55 meanwhile acts to move the exhalation check valve 35 to its former seated position against the valve element 49. Hence, regardless of what the condition may be within the supply passage

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16, whether it be lower pressure as a result of pull upon the hose or higher pressure where such pull is released, the valves 34 and 35 will continue to operate regularly and effectively even though there may be a shift in position of the composite sleeve 33. Hence, pressure needed to operate both valves remains perfectly normal under such extraordinary circumstances and breathing continues with the same comfort and effort as exists when there is no pull upon the hose.

Attention is directed to the diameter of the exhalation valve 49 defined by the knife-edge engagement with the face of the exhalation check valve 34. This diameter establishes an area on the left-hand or exhalation side of the axially shiftable sleeve of some predetermined fixed amount. This area is responsive to exhalation pressure when the person using the device expels air from his lungs, at which time the inhalation check valve 34 is closed and comprises a portion of the area.

There is correspondingly an area on the opposite or right-hand side of the axially shiftable sleeve which is responsive to pressure in the supply passage 16 connected as shown to the hose 15. The effective area on the last mentioned side of the axially shiftable sleeve is the area encompassed within the circumference of the apex of the flexible annular seal 50. This being a flexible element, something less than the entire breadth of the seal is responsive in full to the supply pressure and it is clear that one-half of the breadth of the seal is thus responsive, this being the half located diametrically inwardly with respect to the apex. Since the circumference at the apex of the flexible annular seal 50 is obviously very much greater than the circumference at the point of the knife edge of the exhalation valve seat, it is obvious that if pressures on opposite sides of the axially shiftable sleeve were the same, then the area on the right side being greater, the sum total pressure on that side would be greater and the sleeve would tend to move from right to left.

When there is a depletion of oxygen in the supply line, a new condition prevails. Initially when inhalation is taking place, the inhalation check valve 34 is lifted from its seat and a negative pressure induced by the inhalation effort is set up and becomes the same on both sides of the check valve because the valve is open. In other words, when the user inhales and thus reduces the pressure in the mask, he simultaneously reduces the pressure by the same amount on the right-hand side or supply side of the axially shiftable seal which is in effect the exhalation valve. Thereafter during the normal inhalation cycle when the negative pressure induced is less than that created initially the forces acting on the valve element will react in a direction causing the exhalation valve to open and stay open until the negative pressure is broken on the supply side. This occurs because the area on the right-hand side where the greater negative pressure exists is greater than the area on the mask side where the lesser negative pressure prevails. By way of explanation it should be noted that if the areas were the same there would be a balance of forces on opposite sides and the exhalation valve would remain seated. The reaction is in essence the reverse of the reaction which would occur if the pressures were positive pressures. The unseating condition described converts the exhalation valve into an ambient air port so that the subject can inhale ambient air and hence suffocation is prevented. The phenomena is particularly effective due to the hose pull protection feature embodied in the movable character of the exhalation check valve 35 relative to the axially shiftable sleeve. With the proper design of the hose pull protection seal 45, the sensitivity of this anti-suffocation feature can be controlled and the level of suction required to provide anti-suffocation can be controlled by both the differential areas and the resistance across the hose pull protection seal.

Moreover, from the type of construction herein described it will be understood that the base and cap can be

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separated from each other very readily by removal of the screws 27, in which event the spacer can also be removed and together with it all portions of the composite sleeve 33. The last identified sleeve carrying all moving parts with it can readily be replaced if need be with a new composite sleeve without any readjustment being necessary and the sleeve mentioned after removal can be serviced or repaired at a location equipped especially with tools and jigs for that purpose.

In another form of the invention shown in FIGURE 3, there is provided also a combination inhalation-exhalation valve device including the anti-suffocation feature but including also sundry refinements. In this form there is a valve body indicated generally by the reference character 60 and consisting of a mask end element 61 and a hose end element 62. These elements are joined together through a spacer 63 by means of screws 64. The spacer contains one or more openings or ports 65 which comprise the exhalation port means. In the mask end element is a supply passage 66 which is supplied by gas from the passage 67 in a hose 68 in order to pass the gas into the interior of the valve device through a passage indicated generally by the reference character 69. Within and forming in part the passage 69 is a tubular assembly 70 which consists essentially of an outer sleeve 71 and an inner sleeve 72, having reference to the relative diameters of the sleeves. The outer sleeve extends partially into an annular pocket 73 formed in the hose end element 62, the pocket having an outer edge 74 and an inner edge 75. To properly secure the sleeve, namely, the outer sleeve 71 in the position shown in FIGURE 3, there is provided a ring 76 of flexible material, annular in shape, and including a bead 77 at its outer extremity secured to the outer edge 74. A somewhat similar bead 78 at its inner extremity is secured to the inner edge 75 by employment of a retaining ring 79. The ring 76 essentially closes the pocket 73 except for the provision of a vent passage 80 which communications between the pocket 73 and the supply passage 66.

The ring 76 is connected by another retaining ring 81 to the inner sleeve 71 at its outer face and adjacent the end which is received within the pocket 73. From this description it will be clear that the outer sleeve 71 is essentially centered as well as supported by the double folds of the ring 76 in a fashion which is capable of guiding the sleeve during movement and also holding it properly in place. The inner sleeve 72 is connected to the outer sleeve throughout a sealed joint 83 of some appropriate conventional design which makes the seal tight and also which makes the sleeves rigid with respect to each other. At the left end of the inner sleeve 72 is a spider 84 providing a central area 85 by means of which a valve stem 86 is retained, thereby to attach an inhalation check valve 87 in position. A rim 88 of the inhalation check valve seats upon an annular seat 89 so that upon inhalation when the inhalation check valve 87 is lifted from its seat, air or oxygen will flow into a combined inhalation-exhalation chamber 90 and thus be available for breathing.

A spool spring 91 seated on a shoulder 92 on the hose end element 62 and upon a similar shoulder 93 in the inside sleeve 72 normally tends to urge the tubular assembly endwise in a direction from right to left so that a valve face or valve face element 94 is seated upon an exhalation valve seat 95.

It will be noted in the form of invention of FIGURE 3, similar to the form of invention of FIGURES 1 and 2, the exhalation valve seat 95 defined by the knife edge circumscribes an area on the tubular assembly which is subject to exhalation pressure. There is also an area on the opposite side of the tubular assembly subject to pressure in the supply line. The pressure acts in part directly upon the tubular assembly and also through the vent passage 80 into the pocket 73 and there against portions of the tubular assembly. The effective area subject to supply

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line pressure is circumscribed by the apex of a loop 96 forming part of the ring 76, the loop 96 being exterior with respect to the outside sleeve 71. An inside loop 77 is likewise subject to the same pressure but entirely throughout its available area. Moreover, the area circumscribed by the apex of the loop 96 is greater than the area circumscribed by the exhalation valve seat. Hence, there is a greater area on the right side or supply side of the tubular assembly subject to gas pressure than the area on the opposite side or mask side.

In this embodiment also under circumstances where there might be a failure of supply when the subject inhales, pressure on the mask side will be reduced. Simultaneously pressure will be reduced to a negative pressure of the same amount upon the opposite side or supply side of the tubular assembly. Since the area on the latter side is greater than the area on the mask side, the forces acting on the tubular assembly as a valve member will react as previously described in a direction causing the exhalation valve to open, thus converting the exhalation valve into an ambient air port, converting the valve device into an anti-suffocation valve. This is because the exhalation valve will remain open under those special circumstances and permit the subject to breathe ambient air, thus to fill his lungs with a complete tidal volume, even though there may be a shortage of oxygen at the supply.

In operation otherwise, when the subject inhales, the inhalation check valve 87 will be lifted and thus permit oxygen to pass into the combined inhalation-exhalation chamber 90 and thus be available for breathing. During this portion of the cycle the spring 91 acting in the direction shown will move the tubular assembly and cause the valve face or exhalation valve element 94 to seat upon the seat 95. When thereafter the subject exhales, the inhalation check valve is closed and pressure upon the respective side of the tubular assembly overcomes pressure of the spring 91 and the supply pressure, causing the tubular assembly to shift from left to right, opening the exhalation valve so that the subject can exhale. This movement is cushioned by the necessity of gas trapped within the pocket 73 to pass out of the pocket through the restricted vent 80. The vent is restricted to slightly retard movement of the tubular assembly, although not to hinder it objectionably. This damping action of the vent coupled with the multiple flexible mounting of the sleeve 71 assures a smoothness in the reciprocating action of the sleeve. It accordingly prevents chatter and particularly is effective when there might be a rapid breathing by the subject under particular circumstances where a clatter or rattle might be objectionable. Moreover, constructed as shown the fabrication of the parts can be simplified and improved. Grinding and lapping of the valve face 94 is made particularly easy before the inner sleeve 72 has been applied. Attachment of the ring 76 is a simple operation by employment of the retaining ring 81 as is also attachment by employment of the retaining ring 79 during initial assembly stages. Attachment of the bead 77 at the outer extremity can be readily made by first impressing the bead into an appropriate annular recess 98 by hand and thereafter firmly anchoring it in place merely by assembling the mask end element and hose end element upon the spacer 63. As shown and described, the parts are rugged and by virtue of the design need not be held to difficult tolerances but at the same time provide a dependable valve having the improved safety features herein set forth.

While the invention has herein been shown and described what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described the invention, what is claimed as new in support of Letters Patent is:

1. A composite inhalation-exhalation valve device with low pressure protection comprising a valve body having a passage therethrough and a supply connection thereon for a supply hose in communication with said passage, a sleeve within said passage and movable axially relative to the passage, and a flexible connection between the exterior of the sleeve and the body, an inhalation valve passage at one end of the sleeve forming a communication between the end of the passageway adjacent the supply connection and the opposite end, said sleeve on the supply side thereof having a first area responsive to pressure in the supply passage of a predetermined amount, and an inhalation check valve element normally closing said passage, a first annular exhalation valve component on said body, exhalation passage means forming an exhalation port through the body adjacent said exhalation valve component, a second exhalation valve component mounted on the sleeve, one of said components comprising an exhalation valve element and the other of said components comprising an exhalation valve seat, said exhalation valve seat at the line of engagement with the exhalation valve element defining a second area responsive to exhalation pressure, said second area being of lesser amount than said first area whereby to increase the effective total pressure on said first area during the inhalation cycle thereby to inhibit suffocation when the supply hose is no longer capable of supplying the valve device.

2. A composite inhalation-exhalation valve device with low pressure protection comprising a valve body having a passage therethrough and a supply connection thereon for a supply hose in communication with said passage, a sleeve within said passage and movable axially relative to the passage, and a flexible connection between the exterior of the sleeve and the body, an inhalation valve passage at one end of the sleeve forming a communication between the end of the passageway adjacent the supply connection and the opposite end, said sleeve on the supply side thereof having a first area responsive to pressure in the supply passage of a predetermined amount, and an inhalation check valve element normally closing said passage, a first exhalation valve component on said body, exhalation passage means forming an exhalation port through the body adjacent said exhalation valve component, a second exhalation valve component mounted on the sleeve and a flexible connection between said second exhalation valve component and the sleeve, one of said components comprising an exhalation valve element and the other of said components comprising an exhalation valve seat, said exhalation valve seat at the line of engagement with the exhalation valve element defining a second area responsive to exhalation pressure, said second area being of lesser amount than said first area whereby subsequent to depletion of supply to decrease the effective total pressure on said first area during the inhalation cycle thereby to inhibit suffocation, and resilient means acting between the body and the exhalation

tion valve element normally urging said exhalation valve element to a seated position whereby to enable movement of the sleeve in a direction toward the supply connection unaccompanied by movement of the exhalation valve away from seated position.

3. A composite inhalation-exhalation valve device comprising a valve body having a passage therethrough and a supply connection thereon, a tubular assembly within said passage movable axially relative to the passage, said assembly comprising an outer sleeve and an inner sleeve joined together at adjacent ends with a sealed joint, said body comprising a spacer having an exhalation port therein, a mask end element and a hose end element releasably joined together and to said spacer, said mask end element having an annular exhalation valve seat thereon, an annular exhalation valve element on said outer sleeve movable to seated and unseated positions relative to said seat, said supply end element having an annular pocket adjacent said outer sleeve adapted to receive said outer sleeve when the valve element is in unseated position, and a restricting vent passage between the pocket and the passage at the supply end thereof, an annular flexible connection between said outer sleeve and said supply end element comprising a ring of sheet material having an inner edge connected to the mask end element at an inside edge of the pocket, an outer edge connected to the mask end element at the outer edge of the pocket and a mid-portion connected to said outer sleeve whereby to provide a plurality of flexure connections between the outer sleeve and the body, an inhalation check valve passage in said inner sleeve between the supply end element and the mask end element and an inhalation check valve operably mounted on said seat, resilient means acting between said body and said tubular assembly normally urging said exhalation valve element to seated position, said tubular assembly having an area on the supply side subject to a negative pressure upon depletion of the supply greater than an area on the mask side thereof defined by said exhalation valve when subject to a comparable negative pressure whereby to inhibit suffocation.

References Cited in the file of this patent

UNITED STATES PATENTS

2,820,469	Seeler	Jan. 21, 1958
2,936,779	Kindred	May 17, 1960
2,954,793	Seeler	Oct. 4, 1960

FOREIGN PATENTS

1,105,803	France	July 6, 1955
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OTHER REFERENCES

New Valve for Non-Rebreathing Systems, M. Jack Frumin et al., *Anesthesiology*, vol. 20, No. 3, May-June 1959, pp. 383-385. (A copy of this publication is found in the Washington, D.C. libraries of the following institutions: National Library of Medicine and National Institution of Health.)